U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE
SUBCOMMITTEE ON ENERGY
SUBCOMMITTEE ON RESEARCH

JOINT HEARING CHARTER

Fueling the Future: On the Road to the Hydrogen Economy

Wednesday, July 20, 2005
10:00 a.m. to Noon
2318 Rayburn House Office Building

1. Purpose

On Wednesday, July 20, 2005, at 10:00 a.m., the Energy and Research Subcommittees of the House Science Committee will hold a joint hearing to examine the progress that has been made in hydrogen research since the launch of the President's Hydrogen Initiative and the next steps the Federal government should take to best advance a hydrogen economy.

2. Witnesses

Mr. Douglas Faulkner is the Acting Assistant Secretary for Energy Efficiency and Renewable Energy at the Department of Energy (DOE).

Dr. David Bodde is the Director of Innovation and Public Policy at Clemson University's International Center for Automotive Research (ICAR).

Mr. Mark Chernoby is Vice President for Advanced Vehicle Engineering at the DaimlerChrysler Corporation.

Dr. George Crabtree is the Director of the Materials Science Division at Argonne National Laboratory.

Dr. John Heywood is the Director of the Sloan Automotive Laboratory at the Massachusetts Institute of Technology.

3. Overarching Questions

The hearing will focus on the following overarching questions:

1. What progress has been made toward addressing the principal technical barriers to a successful transition to the use of hydrogen as a primary transportation fuel since the Administration announced its hydrogen initiatives, FreedomCAR and the President's Hydrogen Fuel Initiative? What are the remaining potential technical "showstoppers?"

2. What are the research areas where breakthroughs are needed to advance a hydrogen economy? How has DOE responded to the report by the National Academy of Sciences (NAS) calling for an increased emphasis on basic research? How is DOE incorporating the results of the Basic Energy Sciences workshop on basic research needs for a hydrogen economy into the research agenda for the hydrogen initiative?

3. The NAS report suggested that the research agenda should be developed with future policy decisions in mind. How has DOE increased its policy analysis capabilities as recommended by the NAS? How will the results of that analysis be applied to the research agenda?

4. Overview

- In his 2003 State of the Union speech, President Bush announced the creation of a new Hydrogen Fuel Initiative, which built on the FreedomCAR initiative announced in 2002. Together, the initiatives aim to provide the technology for a hydrogen-based transportation economy, including production of hydrogen, transportation and distribution of hydrogen, and the vehicles that will use the hydrogen. Fuel cell cars running on hydrogen would emit only water vapor and, if domestic energy sources were used, would not be dependent on foreign fuels.

- Industry is participating in the hydrogen initiatives, and has invested heavily in hydrogen technology, particularly the automobile manufacturers and oil companies. The FreedomCAR program is a partnership between Ford, GM, DaimlerChrysler, and the federal government, and the President's Hydrogen Fuel Initiative expanded that partnership to include major oil companies such as Shell and BP, and merchant producers of hydrogen like Air Products and Chemicals, Inc. Although exact amounts of industry investment are proprietary, GM alone is estimated to have spent over $1.5 billion, and other automakers have invested similar amounts.

- The National Academy of Sciences (NAS) recommended changes to the hydrogen initiatives in its 2004 report, *The Hydrogen Economy: Opportunities, Costs, Barriers, and R&D Needs*. The report particularly stressed the need for a greater emphasis on basic, exploratory research because of the significant technical barriers that must be overcome. DOE has responded by expanding the hydrogen program into the Office of Science, and has requested $33 million for fiscal year 2006 (FY06) to fund basic research efforts in DOE's Office of Science.

- In addition, the NAS report noted that DOE needs to think about policy questions as it develops its research and development (R&D) agenda: "Significant industry investments in advance of market forces will not be made unless government creates a business environment that reflects societal priorities with respect to greenhouse gas emissions and oil imports…The DOE should estimate what levels of investment over time are required – and in which program and project areas – in order to achieve a significant reduction in carbon dioxide emissions from passenger vehicles by mid-century." DOE has expanded its hydrogen policy and analysis efforts to be able to answer questions like those posed by

the NAS, but the analytical work is still in progress, and available results are still preliminary.

- Even with the most optimistic of assumptions, it will take some time for hydrogen vehicles to compose a significant part of the automobile fleet. The NAS estimates that sales of hydrogen vehicles will not be significant enough for the full benefits of a hydrogen economy to be realized at least until 2025.

- During the transition to a hydrogen economy, many of the technologies being developed for hydrogen vehicles, such as hybrid systems technology and advanced lightweight materials could be deployed in conventional automobiles to provide reduced oil dependence and emissions. Without the proper incentives, vehicle improvements are likely to continue to be used to increase performance, rather than improving fuel economy, as they have been for the past twenty years. The Environmental Protection Agency estimates that if today's vehicles had the same weight and acceleration as cars did in 1987, they would get 20 percent better gas mileage due to technology improvements.

5. Background

What are the technical challenges?

Major advances are needed across a wide range of technologies for hydrogen to be affordable, safe, cleanly produced, and readily distributed. The production, storage and use of hydrogen all present significant technical challenges. While the research effort at DOE has produced promising results, the program is still a long way from meeting its goals in any of these areas.

Hydrogen does not exist in a usable form in nature, and has to be produced from something else, such as coal or natural gas. But one goal of using hydrogen is to reduce emissions of carbon dioxide. If hydrogen is to be produced without emissions of carbon dioxide, then the technology to capture and store carbon dioxide while making hydrogen must improve significantly. The other main goal of using hydrogen is to reduce the use of imported energy. Today most hydrogen is produced from natural gas, but in order to supply the entire transportation sector significant imports of natural gas would be required. Other possible means of producing hydrogen, including nuclear energy and renewable energy sources, are inherently cleaner than coal, but are far from affordable with existing technology.

Another major hurdle is finding ways to store hydrogen, particularly on board a vehicle. Hydrogen is a small molecule with properties that make it difficult to store in small volumes and in lightweight materials. The American Physical Society argued in its 2004 report on hydrogen, *The Hydrogen Initiative*, that a new material would have to be discovered in order to meet the FreedomCAR goals.

The NAS estimated that fuel cells themselves would need a ten- to twenty-fold improvement before fuel cell vehicles become competitive with conventional technology. Large improvements have been made since the report has been released, but additional improvements are still needed. DOE estimates that roughly a five-fold decrease in cost will be required, while at the same time increasing performance and durability. Current fuel cells wear out quickly, and lifetimes are far

short of those required to compete with a gasoline engine. Small-scale distributed hydrogen production also needs improvement, and the NAS report recommended increased focus in that area because it may be among the first hydrogen-related technologies to be deployed.

What are the non-technical challenges, in the policy and regulatory areas?

Since many of the benefits of a hydrogen economy, such as reduced greenhouse gas emissions, are not currently accounted for in the marketplace, it will be difficult for hydrogen vehicles to compete with conventional technology. Even if all the technical challenges are met, and industry has the capability to produce hydrogen vehicles that are competitive with conventional vehicles, a successful hydrogen economy is not guaranteed. First, the transition to a hydrogen economy will require an enormous investment to create a new infrastructure. Changes in regulation, training and public habits and attitudes will also be necessary. Estimates of the cost of creating a fueling infrastructure (replacing or altering gas stations and distribution systems) alone are in the hundreds of billions of dollars. DOE is initiating an effort to better understand the economics and influences of policy incentives on a possible transition to hydrogen.

How are the Hydrogen Initiatives funded?

The FreedomCAR and the Hydrogen Fuel Initiative are expected to cost $1.7 billion over 5 years from FY03 to FY08. The President called for $358 million across DOE for these programs in the FY06 request, an increase of $48 million, 16 percent over levels appropriated for the initiatives in FY05. However, this increase comes at a time when R&D programs in the other energy efficiency and renewable energy programs are seeing decreasing requests overall, by $74 million, 10 percent to $692 million. Unless additional funding is provided to renewable energy and energy efficiency programs at DOE in general, the projected further increases in the FreedomCAR and Hydrogen Fuel Initiative will likely result in more cuts to other efficiency and renewable programs.

	FY04 appropriation (in millions)	FY05 appropriation (in millions)	FY06 Request (in millions)	$ Change from FY05 Level	% Change from FY05 Level
Hydrogen Fuel (EERE only)	$145	$169	$183	$14	8%
FreedomCAR	$150	$160	$184	$24	15%
HFI and FreedomCAR (without duplications)	$232	$254	$283	$29	11%
Fossil Energy	$5	$17	$22	$5	29%
Nuclear Energy	$6	$9	$20	$11	124%
Office of Science	$0	$29	$33	$3	11%
Total DOE Hydrogen	$243	$309	$358	$48	16%
DOT	$1	$1	$2	$2	328%
Grand Total	$243	$310	$360	$50	16%

Technology Background

What is a Fuel Cell?

Central to the operation of the hydrogen-based economy is a device known as a fuel cell that would convert hydrogen fuels to electricity. In cars, these devices would be connected to electric motors that would provide the power now supplied by gasoline engines. A fuel cell produces electricity by means of an electrochemical reaction much like a battery. There is an important difference, however. Rather than using up the chemicals inside the cells, a fuel cell uses hydrogen fuel, and oxygen extracted from the air, to produce electricity. As long as hydrogen fuel and oxygen are fed into the fuel cell, it will continue to generate electric power.

Different types of fuel cells work with different electrochemical reactions. Currently most automakers are considering Proton Exchange Membrane (PEM) fuel cells for their vehicles.

Benefits of a Hydrogen-based Economy

A hydrogen-based economy could have two important benefits. First, hydrogen can be manufactured from a variety of sources, including natural gas, biofuels, petroleum, coal, and even by passing electricity through water (electrolysis). Depending on the choice of source, hydrogen could substantially reduce our dependence on foreign oil and natural gas.

Second, the consumption of hydrogen through fuel cells yields water as its only emission. Other considerations, such as the by-products of the hydrogen production process, will also be important in choosing the source of the hydrogen. For example, natural gas is the current feedstock for industrial hydrogen, but its production releases carbon dioxide; production from coal releases more carbon dioxide and other emissions; and production from water means that pollution may be created by the generation of electricity used in electrolysis. Production from solar electricity would mean no pollution in the generation process or in consumption, but is currently more expensive and less efficient than other methods.

6. Witnesses Questions

The witnesses have been asked to address the following questions in their testimony:

Mr. Douglas Faulkner:

- What progress has been made toward addressing the principal technical barriers to a successful transition to the use of hydrogen as a primary transportation fuel since the Administration announced its hydrogen initiatives, FreedomCAR and the President's Hydrogen Fuel Initiative? What are the remaining potential technical "showstoppers?"
- What are the research areas where breakthroughs are needed to advance a hydrogen economy? How has DOE responded to the report by the National Academy of Sciences (NAS) calling for an increased emphasis on basic research? How is DOE incorporating the results of the Basic Energy Sciences workshop on basic research needs for a hydrogen economy into the research agenda for the hydrogen initiative?
- The NAS report suggested that the research agenda should be developed with future policy decisions in mind. How has DOE increased its policy analysis capabilities as

recommended by the NAS? How will the results of that analysis be applied to the research agenda?
- How is DOE conducting planning for, and analysis of, the policy changes (such as incentives or regulation) that might be required to accelerate a transition to hydrogen? What other agencies are involved in planning for, or facilitating, such a transition?

Mr. Mark Chrenoby:

- What criteria does DaimlerChrysler consider when making investment decisions regarding its portfolio of advanced vehicle research and development programs? What factors would induce DaimlerChrysler to invest more in the development of hydrogen-fueled vehicles? What do you see as a probable timeline for the commercialization of hydrogen-fueled vehicles? What about the other advanced vehicle technologies DaimlerChrysler is currently developing, such as hybrid vehicles and advanced diesel engines?
- What do you see as the potential technology showstoppers for a hydrogen economy? To what extent is Daimler relying on government programs to help solve those technical challenges?
- How are automakers using, or how do they plan to use, the advanced vehicle technology developed for hydrogen-fueled vehicles to improve the performance of conventional vehicles?

Dr. David Bodde:

- What progress has been made toward addressing the principal technical barriers to a successful transition to the use of hydrogen as a primary transportation fuel since the Administration announced its hydrogen initiatives, FreedomCAR and the President's Hydrogen Fuel Initiative? What are the remaining potential technical "showstoppers?"
- What are the research areas where breakthroughs are needed to advance a hydrogen economy? How has DOE responded to the report by the National Academy of Sciences (NAS) calling for an increased emphasis on basic research? How is DOE incorporating the results of the Basic Energy Sciences workshop on basic research needs for a hydrogen economy into the research agenda for the hydrogen initiative?
- Is the current balance between funding of hydrogen-related research and research on advanced vehicle technologies that might be deployed in the interim before a possible transition to hydrogen appropriate? What advanced vehicle choices should the federal government be funding between now and when the transition to a hydrogen economy occurs? How are automakers using, or how do they plan to use, the advanced vehicle technology developed for hydrogen-fueled vehicles to improve the performance of conventional vehicles? Are automakers likely to improve fuel economy and introduce advanced vehicles without government support? How will ICAR encourage automakers to introduce technologies to improve fuel economy?
- What role do entrepreneurs, start-up companies, and venture capital investors have to play in accelerating the commercial introduction of advanced hydrogen-fueled vehicles?

Dr. George Crabtree:

- What progress has been made toward addressing the principal technical barriers to a successful transition to the use of hydrogen as a primary transportation fuel since the Administration announced its hydrogen initiatives, FreedomCAR and the President's Hydrogen Fuel Initiative? What are the remaining potential technical "showstoppers?"
- What are the research areas where breakthroughs are needed to advance a hydrogen economy? How has DOE responded to the report by the National Academy of Sciences (NAS) calling for an increased emphasis on basic research? How is DOE incorporating the results of the Basic Energy Sciences workshop on basic research needs for a hydrogen economy into the research agenda for the hydrogen initiative?
- The NAS report suggested that the research agenda should be developed with future policy decisions in mind. How has DOE increased its policy analysis capabilities as recommended by the NAS? How will the results of that analysis be applied to the research agenda?
- How is DOE conducting planning for, and analysis of, the policy changes (such as incentives or regulation) that might be required to accelerate a transition to hydrogen? What other agencies are involved in planning for, or facilitating, such a transition?

John Heywood:

- How might the future regulatory environment, including possible incentives for advances vehicles and regulations of safety and emissions, affect a transition to hydrogen-fueled motor vehicles? How could the Federal government most efficiently accelerate such a transition?
- Is the current balance between funding of hydrogen-related research and research on advanced vehicle technologies that might be deployed in the interim before a possible transition to hydrogen appropriate? What advanced vehicle choices should the federal government be funding between now and when the transition to a hydrogen economy occurs? How are automakers using, or how do they plan to use, the advanced vehicle technology developed for hydrogen-fueled vehicles to improve the performance of conventional vehicles? Are automakers likely to improve fuel economy and introduce advanced vehicles without government support?
- What role should the Federal government play in the standardization of local and international codes and standards that affect hydrogen-fueled vehicles, such as building, safety, interconnection, and fire codes?